International Journal of Exploring Emerging Trends in Engineering (IJEETE)
Vol. 03, Issue 02, Mar-Apr, 2016 Pg. 107 - 111 WWW.IJEETE.COM

EFFECT OF PROCESS PARAMETRES ON MECHNICAL PROPERTIES OF HOT AIR WELDED PVC PLASTICS

Gulam Rasul[1] Mahmood Alam[2] Dr. Mohd. Anas[3]
1 Research scholar, Department of Mechanical engineering Integral University, Lucknow, India
2 Assistant Professor, Department of Mechanical engineering Integral University, Lucknow, India
3. Associate professor Department of Mechanical engineering Integral University, Lucknow, India

ABSTRACT - *The goal of the paper is to investigate mechanical properties of hot air welded PVC plastics for different process parameter .Hot air welding technique is considered to be the most significant development in metal joining during last decade. In the present work an effort has been made to join the PVC plastics by hot air welding technique the effects of critical process parameters on mechanical properties i.e. tensile and impact strength of hot air welded PVC plastics have been studied. Three process parameters i.e. Mass flow rate of hot air, current and weld speed were taken as process variables are varied at two levels as higher level and lower level. Higher tensile strength can be achieved at higher current and also study the hard plastics PVC material properties for better impact and tensile strength.*

Keywords— X grooves, Polyvinyl chloride (PVC), Travel speed, welded bead

INTRODUCTION

Development of plastic joining technology is now very important for the advancement of the car industry, telecommunications, and the construction industry and medical Technology [1].The plastics materials are increasingly being used in structure and engineering application. In all markets including automobile, Appliance, and electrical, there is a higher Demand of plastics materials to produce more complex and stable parts than ever. Plastics offers many advantages over traditional materials, such as low weight, low cast, easy processing and ease of modification for various applications,[2]. Hot gas welding is one of the external heating methods and In this method, a weld groove and a welding rod were heated with hot gas stream until they soften sufficiently to fuse; then, the welding rod is pressed into the weld groove [3]. There are a number of methods to weld thermoplastics, which include hot gas (air) hand welding, hot gas (air) extrusion welding, butt fusion (heated element welding), friction welding, laser welding and high frequency welding. In the following, hot gas (air) hand welding and hot gas (air) extrusion welding are being addressed since they play a major role in the field of custom thermoplastic fabrication. A further application for these techniques is the modification or repair of rotationally molded, blow molded, vacuum formed or injection molded parts [4].

Basic process parameters of hot air plastics welding:-The joining parameters of hot air welding process are [5]

TABLE-1 process parameter along with description

Process parameters	Discretion
Temperature	Temperature of hot gas
Gas	Composition of hot gas(air, carbon dioxide, hydrogen, oxygen or nitrogen)
Angle	Include angle between weldment and rod, angle between gas nozzle and weldment.
Travel Speed	Rate at which weld is being deposited.
Weld Force	Amount of force applied to the filler rod.
Filler Rod	Composition of filler rod.
Gap Distance	Distance between gas nozzle and workpiece.
Weld Joint	butt joint and double strap fillet joint.
Pressure of Hot air/gas	Pressure of gas at which it coming out from nozzle.
Shoe	Design and size of welding nozzle

1. **Air/gas temperature;** Air temperature depends on the type of polymer being joined, and which determines the heating elements, nozzle dimension and gas/air flow rates that are used[5]
2. **Gas**: Generally gas used for welding is air or N[5]
3. Angle; - Generally angle between the filler rod and weldment is taken as 90degree and between gas nozzle and weldment is 45degree.[5]

4. **Travel speed;** the difficulty in maintaining a constant desired traverse speed is overcome by using milling machine table traverse. Or travel speed can be measure by dividing the distance traveled of filler rod by time taken to travel this distance [5].
5. **Weld force:** Best result attains when welding force applied on the weld in the range of 10-20 N when welding shoe is employed, however, it is approximately 5 N[5].
6. **Filler rod:** The composition of filler rod is must be similar to the polymer being welded[5].
7. **Gap distance;** There is effect seen on varying the gap distance between the gas nozzle and work piece. plot of gap distance versus temperature is obtained as shown in figure[5]

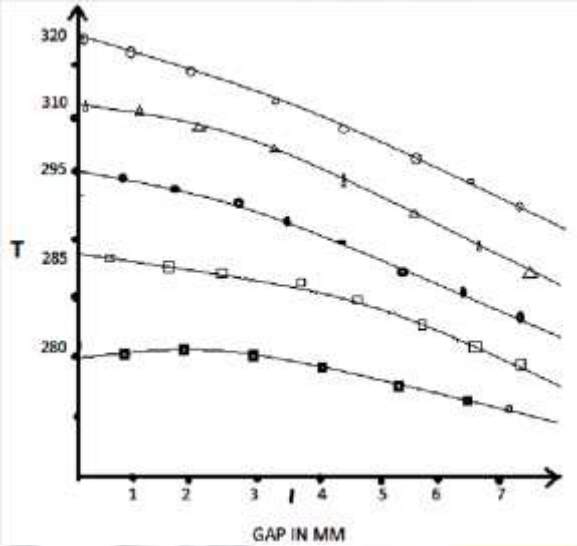
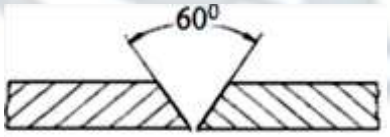
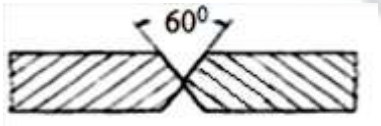


FIG-1 Graph between temperature and gap distance

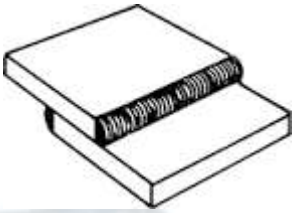
8. **Welded joints:** generally two types of are used (a) but joint (b) Lap joint. The sheet edges were cut to produce 60^0 single V-grooves and double V-grooves (X-grooves) shown in figure[5]



(a)



(b)



(c)

FIG-2 joint preparation (a) Single V-weld groove (b) Double V-weld groove (c) welded bead

9. **Pressure of hot gas/air**: pressure can be varied from 1.4 –2.8 MPa when shoe is employed. However it is approximately 0.7 MPa [5].

Work Piece (Hard plastic PVC) material prosperities- PVC Detailed Properties(Polyvinyl chloride)- The table below lists a generally accepted summary of properties that we believe to be reliable.[6]

TABLE-2 Mechanical Properties of PVC

PVC PROPERITES-	ASTM	UNIT
Specific Gravity	D792	1.3~1.7
Elongation	D638	%(24~145)
Tensile Strength	D638	Psi(7,300)
Flexural Strength	D790	Psi(4,060~14,100)
Compressive Strength	D695	7,250~8,120
Tensile Elastic Modulus (Young's Modulus)	D638	(10~5) psi
Flexural Modulus	D790	(10~5) psi
Hardness Durometer	D785	Rockwell R(107~113)
Impact Strength IZOD 73°F/23°C	D256	notched ft/lbs/in(0.4~20)

Mechanical properties-PVC has high hardness and mechanical properties. The mechanical Properties enhance with the molecular weight increasing but decrease with the temperature increasing.
The mechanical properties of rigid PVC (PVC) are very good; the elastic modulus can reach 1500-3,000 MPa. The soft PVC (flexible PVC) elastic is 1.5-15 MPa [7].

Mechanical properties of welded PVC sheets-, Impact strengths of both single and double V-welds on PVC sheets were improved significantly by using the welding shoe. Izod impact tests showed that the weld roots absorb less impact energy than the weld face for single V-welded

PVC sheets. This was likely the result of some weaknesses such as pores and unfused regions because of lower welding pressure on the weld root. In addition, weldability (RW) of the weld face might be better than the weld root because shear rate and temperature of the weld face are higher than those of the weld root . When impacts were performed on the first seam for double V-welded and PVC with the welding shoe, the impact strengths attained highest values, 35.0 kJ $m^{-2}$and 23.6 kJ m^{-2}, respectively. [8]

Effect of input parameter on mechanical properties-The effect of input parameter has been studied on tensile strength of the weld bead by using full factorial design and tensile strength has been measured as the response parameter. Regression analysis has been carried out for all the responses to analyze the significance of the input parameters. Regression equation has been developed to predict the relationship amongst the dependent and independent variables [9].

Table 3: Regression table for Tensile Strength of weld bead

Predictor	Coef	SE Coef	T	P
Constant	-4.497	3.565 -	1.26	0.276
I	2.763	2.003	1.38	0.240
S	0.201	1.041	0.19	0.856
Q	0.0001057	0.0000604	1.75	0.156

Residual is the difference between the observed and fitted value of the response. There are four different plots are available as normal probability plot, histogram, versus fit and versus order as shown in given graphs [9]

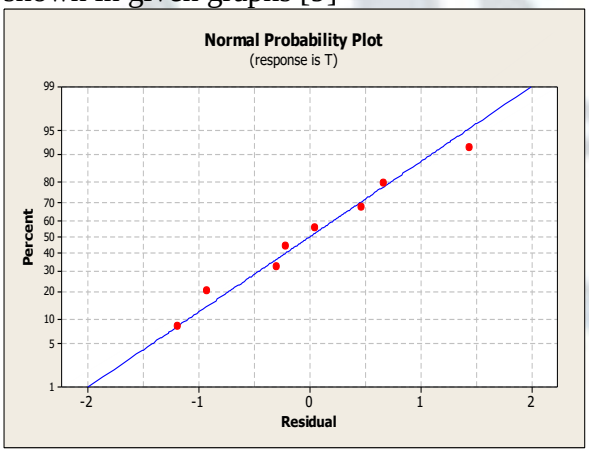


FIG 3 Normal probability plots for Tensile Strength

1. hot air weld speed and welding current- Welding current has been found to be a significant factor in regard to tensile strength with p value of 0.240 (table 3). Apart from weld current other significant factor is weld speed but it is lesser significant than weld current. The p value of speed is 0.856(table 3). Mass flow rate did not show any significant impact on the tensile strength of the weld bead [9]. Maximum value of tensile strength can be calculated by the model developed as Tensile strength (T) = - 4.50 + 2.76 I + 0.20 S + 0.000106 Q ,The maximum value of tensile strength predicted by above formula is 2.476688 (table 6) which is shown in given Table6 and obtained at higher level of weld current[9].

(2)Mass flow rate of hot air-The effect of input parameter was studied on tensile strength, stiffness and resilience of the weld bead by using Regression analysis and full factorial design. Tensile strength, Stiffness and Resilience were measured as the response parameter. Regression analysis was completed for all the responses to analyze the significance of the input factors. Regression equation was developed to predict the relationship amongst the dependent and independent variables. Table 6 shows the values of responses measured [10].

TABLE-4 Thermal Properties of PVC

	Unit	PVC
Melting Point	°C (°F)	182 (360)
Upper Service Temperature(20,000h)	°C (°F)	60 (140)
Flame Rating**	UL94	VO
Thermal Conductivity	10~4 cal/sec/cm2,°C/cm	3.0~5.0

Thermal and fire properties-The heat stability of raw PVC is very poor, so the addition of a heat stabilizer during the process is necessary in order to ensure the product's properties. PVC starts to decompose when the temperature reaches 140 °C, with melting temperature starting around 160 °C. The linear expansion coefficient of rigid PVC is small and has good flame retardancy, the Limiting oxygen index (LOI) being up to 45 or more. The LOI is the minimum concentration of oxygen, expressed as a percentage that will support combustion of a polymer and noting that air has 20% content of oxygen [7].

ELECTRICAL PROPERTIES-	ASTM	PVC
Dielectric Constant	D150	1kHz(3.0~8.0)
Dissipation Factor	D150	1kHz(0.009~0.16)
Dielectric Strength	D149	125 v/mil(300~500)
Volume Resistivity	D257	Ohm cm at 730F, 50% RH(5.4 x 1013)

Electrical properties-PVC is a polymer with good insulation properties, because of its higher polar nature the electrical insulating property is inferior to non polar polymers such as polyethylene and polypropylene. Since the dielectric constant, dielectric loss tangent value, and volume resistivity are high, the corona resistance is not very good, and it is generally suitable for medium or low voltage and low frequency insulation materials [7].

TABLE 5 general properties of PVC

GENERAL PROPERTIES-	ASTM	PVC
Chemical/Solvent Resistance		Excellent
Water Absorption, 24h	D570	%(0.1~1.5)
Refractive Index		1.539

Physical properties-PVC is a thermoplastic polymer. Its properties are usually categorized based on rigid and flexible PVCs[7]..
Applications and Limitations-Plastic welding is used to repair polyolefin tank, container and welding of PVC, ABS, PE and PP pipe section .Apart from this it is also used in automotive industry (repair of bumper) construction, sealing and packaging of material etc[5].

APPLICATIONS AND LIMITATIONS

Plastic welding has wide application in flat and sloping roofs, billboards and tarpaulins, civil engineering etc. Plastic welding is used to repair polyolefin tank, container and welding of PVC, ABS, PE and PP pipe section [5]. Apart from this it is also used in automotive industry (repair of bumper) construction, sealing, packaging of material, electronics and aerospace etc. [11]. The one of the main disadvantage is that the operator must be well skilled and trained otherwise it makes the joint of very less strength or more defective as it should.

CONCLUSION-The present work has been carried out to study the effect of input parameters on mechanical properties of butt welds made on hard PVC plastic using hot air technique. Various parameters (Current, weld speed and mass flow rate of hot air) are varied at two levels as higher level and lower level. Stiffness of the weld bead is mainly affected by welding current and weld speed [10]. higher current [9].

REFERENCES

[1] *Yasuo Kurosaki and Tomoya Matayoshi,*- Study of controllability of melt depth in infrared laser penetration welding of thermoplastics,

[2] Hui-Ming Lu, B.S.M.S. -Analysis of heat flow and residual stress formation during hot plat welding of polycarbonate.

[3] O. Balkan a,*, H. Demirer b, H. Yildirim c , -Morphological and mechanical properties of hot gas welded PE, PP and PVC sheets.

[4]Wegner welding the plastic welding experts(www.wegenerwelding.com)- guidelines for welding thermoplastic materials (hot gas hand and hot gas extrusion welding)

[5] Mahmood Alam1, (Dr.) M.I. Khan2- state-of-the-art in rigid p.v.c. plastic welding by hot air technique(may june-2013)

[6] Wire and cable technical resouress-PVC Polyvinyl Chloride Detailed Property Chart.

[7]Polyvinylchloridehttp://www.vinylplus.eu/uploads/Progress_Report_2011/Vinyl2010-ProgressReport2011_English.pdf

[8] O. Balkan a,*, H. Demirer b, H. Yildirim c-(volume 31 issue 1 november 2008)Morphological and mechanical properties of hot gas welded PE, PP and PVC sheets

[9] Mahmood Alam ,Dr. Shahnawaz Alam Kamran Rasheed(FEB -2015)--Study And Empirical Modeling Relating Welding Parameters And Tensile Strength of Hot Air Welded PVC Plastic.

[10] Mahmood Alam1, Reyaz Ur Rahim2, Mohd. Suhail3- Empirical Modeling Relating Weld Current, Mass Flow Rate of Hot Air and Welding Speed to Stiffness of Hot Air Welded PVC Plastic.

[11] American plastic welding technologies, Hot Air Welding Guide For Plastic Repairs www.bak-ag.com

AUTHOR'S BIBLOGRAPHY

Gulam Rasul student of M-Tech (Final Year) with specialization of production and Industrial Engineering in Integral university Lucknow . and Now working as a Lecturer in Rameshwaram Institute of Technology & Management Lucknow.

Mahmood Alam working as Assistant Professor, Department of Mechanical Engineering, Integral University, Lucknow from last 8 Years. He completed his master degree in production and industrial engineering with specialized work in the field of plastic welding, currently pursuing PhD in the same field.

Dr. Mohd Anas, working as Associate Professor in the Department of Mechanical Engineering, Integral University, Lucknow. He has a teaching experience of 8 years. He completed his masters' degree in Machine Design, AMU, Aligarh. He is awarded PhD on the topic Dynamic Analysis of Composites laminate. His areas of interest are Machine Design, CAD, MSD, Static and Dynamic Analysis, FEM etc.

